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RIP CURRENT AT PANGANDARAN AND PALABUHAN RATU

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ABSTRACT

This research aims to know the causes, types, and mechanisms of the rip current at Pangandaran and Palabuhanratu. The methods used in this research are image data analysis, visual observation, and field observations in June and September 2015. The image data obtained from Google Earth, visual observation with the aid of a video camera and field observations with measurements of oceanographic parameters of a wave, bathymetry, currents, and staining using dye balls. The results showed the length and width of rip currents at Pangandaran around 300 meters and 90 meters, while in Palabuhanratu which ranges from 150 meters and 40 meters. Wave velocity (C) is 1.47 m/s and 1.51 m/s in Pangandaran, 1.13 m/s and 1.04 m/s in Palabuhanratu. The significant wave height (Hs) in Pangandaran is 1.42; while in Palabuhanratu is 1.58 meters. Bathymetry near the beach in both locations showed a morphological appearance of the beach cup with water depth is 0-7 meters in the break zone. Based on the characteristics of the constituent factors, the type of rip currents at Pangandaran and Palabuhanratu is Accretionary beach rip and Topographic rip. Rip current formation process begins with the coming wave passing through surf zone then deflected by the longshore current and returned to the sea away from the shore. Rip currents at Pangandaran and Palabuhanratu formed daily and last throughout the year.

INTRODUCTION

A rip current is part of the surf zone circulation which is driven by a breaking wave and wave bore [1]. Research on rip current is already done in 1936 [2]. Rip current in the world has been examined, among others [1,2,3,4,5,6]. This phenomenon is a combination of some of the dynamics of Oceanography as waveform [7,8,9], current [10], bathymetry [2,10,11].

In Indonesia, this research still rarely done. People on the southern coast of Java believe that the tragedy of the loss of tourists on the South Coast is a mystical incident. This incident is believed to result from the presence of the Queen of the South Coast (Nyai Roro Kidul). If looking at the genesis of tourists dragged down by the current in 2007-2009 at Pangandaran, there are a number of 579 victims (BALAWISTA Regency of Pangandaran). Both of these areas are frequented by tourists both domestic and foreign.

The two areas of this research are related to the open waters of the Indian Ocean. Oceanographic phenomena in these region affected by the Monsoon [13], Java Coast Current [14], with a wave height of 80 cm and with a period of 3.85 seconds [12]. On the condition of the beach that has a large wave, mostly it has permanent rips and fixed rips [10].

The aim of this research is to know the causes, types, and mechanisms of the rip current at Pangandaran and Palabuhanratu. Both locations have often obtained the presence of death due to being swept up by the current. The local language for rip current in both these areas is "arus balik". The main focus of this research is to identify oceanographic factors that are associated with the formation of the rip current. This research used oceanographic parameter measurements such as current, bathymetry, and waves near the coast.

MATERIAL AND METHOD

This research has two locations, there are Citepus Palabuhanratu beach (6°57'51.84"S - 6°58'1.42"S, 106°30'28.80"E - 106°30'46.80"E) and the West Coast of Pangandaran (7°41'11.06"S - 7°41'24.75"S, 108°37'43.24"E - 108°38'26.41"E). The locations of the research can be seen in Figure 1 below:

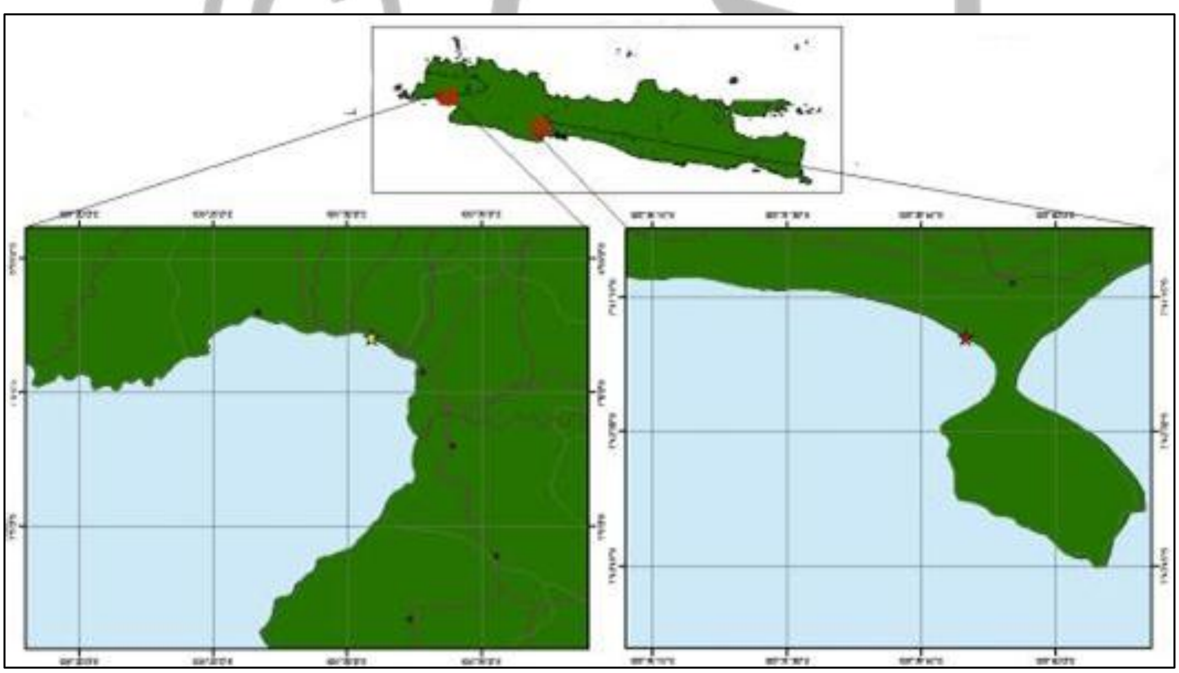

Figure 1. Study Area. Pangandaran (left), Palabuhan Ratu (Right)

Palabuhanratu area is semi-enclosed water while in Pangandaran area is directly related to the open ocean. Both of these areas are directly in contact with the Indian Ocean.

The methods used in this research are by observing the characteristics of wave [7,8,9], and current [7,15,16,17]. Besides that, the observation of rip current is conducted through direct observation or observation through image Google Earth (GE). The reason for using GE is because it is more effective than the other tools and it can describe the real conditions from the environment studied [18]. GE's image data in both locations of the research is the result of a composite of SPOT 5 satellite imagery in 2011 and Digital

Globe satellite imagery in 2006 and 2009. Then, the other methods are the coloring techniques by using dye balls [19] and bathymetry measurements near the coast [2,11,12].

Result and Discussion

The existence of rip current can be seen from turbidity or foam which was in the surf zone, which leads out to the sea away from the coast [6]. From the figure below, there are the appearances of rip currents at Pangandaran through GE, September 2006 and 10 January 2015, and at Palabuhanratu beach on 31 July 2005, 11 June 2006, 4 November 2009, 30 September 2012, and 14 September 2014

Figure 2. The appearance of rip current at Pangandaran (a,b) and Palabuhanratu (c,d,e,f,g)

The appearance of the rip current at Pangandaran in the year of 2006 (Figure a) is 2 rip currents, and in the year of 2015 (Figure b) is 4 rip currents. In the other hand, at Palabuhanratu, there is 3 rip currents in 2005 (Figure c), 4 rip currents in 2006 (Figure d), 2 rip currents in 2009 (Figure e), 2 rip currents in 2012 (Figure f), and 3 rip currents in 2014 (Figure g). The population of the existence of rip current is seasonal resulting from the wave which associated with the type of beach [3]. In 2006, there was the existence of rip current both at Pangandaran and Palabuhanratu respectively by as much as 4 rip currents. The rip current at Pangandaran in 2006 was found in September, while in Palabuhanratu in June. In west monsoon, the wave on the South coast of Java is generally greater than in the East. This condition allows differences which cause different amounts of rip current found in Pangandaran and Palabuhanratu. The time difference can affect the conditions of morphology due to accretion or erosion. Accretion and erosion on the coast effect on the formation of the rip current.

Table 1. The Length and Width of Rip Current.

Location	Year	Coordinate S	Coordinate E	Length	Width
Pangandaran	2006	7°41'14.88"	108°37'56.92"	290 m	98 m
		7°41'18.91"	108°38'11.30"	322 m	103 m
	Average			306 m	100,5 m
	2015	7°41'12.44"	108°37'48.06"	270 m	90 m
		7°41'15.18"	108°38'3.36"	320 m	90 m
		7°41'17.78"	108°38'13.59"	290 m	104 m
		7°41'19.90"	108°38'22.52"	300 m	96 m
	Average			295 m	95 m
	TOTAL Average			**300,5 m**	**97,75 m**
Palabuhanratu	2005	6°57'57.62"	106°30'32.82"	140 m	62 m
		6°58'4.18"	106°30'50.60"	150 m	67 m
		6°58'8.84"	106°31'0.80"	143 m	40 m
	Average			144,3 m	56,3 m
	2006	6°57'55.46"	106°30'36.23"	115 m	50 m
		6°57'59.27"	106°30'44.89"	90 m	46 m
		6°58'0.74"	106°30'49.06"	104 m	60 m
		6°58'6.38"	106°30'59.00"	130 m	102 m
	Average			83,75 m	64,5 m
	2009	6°58'6.45"	106°30'59.76"	123 m	46 m
		6°58'9.42"	106°31'3.60"	80 m	40 m
		6°57'54.37"	106°30'32.90"	120 m	50 m
		6°58'0.74"	106°30'48.21"	90 m	40 m
	Average			103,25 m	44 m
	2014	6°57'54.48"	106°30'34.31"	200 m	90 m
		6°57'57.24"	106°30'39.62"	170 m	75 m
		6°58'6.88"	106°30'58.59"	170 m	80 m
	Average			180 m	81,6 m
	TOTAL Average			**127,8 m**	**61,6 m**

Based on table 1, overall the rip current at Pangandaran in 2006 and 2015 has a length of 300.5 meters and a width of about 97.5 m. In 2006, the length of the rip current reached 322 meters with a width of 103 meters. By 2015, its length is 320 meters and its width of 90 meters. The length of the rip current which was found on the coast of Palabuhanratu average is 127.5 meters with a width of 61.6 m. The average length of the annual Coast Palabuhanratu is in the range of 80–100 meters and a width ranging from 40 meters to 80 meters. Pangandaran is more open towards the ocean, whereas Palabuhanratu is a semi-enclosed bay. The open bay will get a great wave so that the wave in the coast is generally larger. The results of the field observation in Pangandaran and Palabuhanratu did not show the existence of rip current in the same location on the image of GE. This may be due to the existence of rip current which is not fixed. There are 2 rip currents found in Pangandaran. The location of the existence of the rip current at Pangandaran, in point of coordinates 7 ° 41 ' 06 ' S 122 ° 37 ' E ' and 46.33 7 ° 41 ' 17.89 ' S 122 ° 38 ' E ' 17.91. As for the appearance of a rip current in Pan-gandaran, it can be seen in Figure 3.

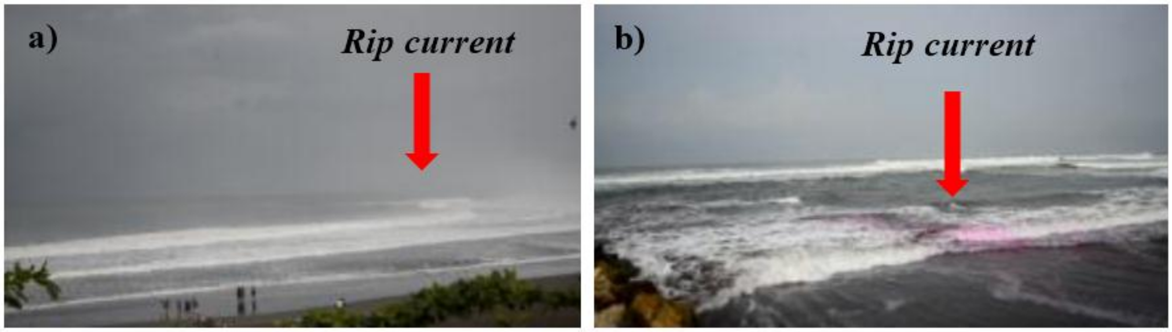

Figure 3. The appearance of rip currrent at Pangandaran; a) observations from the watch tower; b) observations by using dye balls

Figure 3a shows the appearance of a rip current at Pangandaran from the watchtower. The location of the existence of a rip current in accordance with the information of the BALAWISTA, that there was a rip current in the West of Pangandaran. Figure 2b shows the existence of a rip current by looking at the movement of the dye which leads to the sea. The color movement from dye balls took place in some time until finally color from dye balls disappeared towards the sea. As for the movement of color from dye balls, which indicates the existence of a rip current can be seen in Figure 4.

Figure 4. The movement of the color indicates the presence of a rip current in Pangandaran (t = time in seconds)

Based on figure 4, it can be known, dye balls at t = 0 began dipped on waters. At t = 2 dye balls began to spread and led to the sea, at t = 4 and t = 6 dye balls began to fall away from the starting point. At t = 8 and t = 10 dye balls began to spread and moved away. At t = 12 up to t = 22 dye balls already mixed and disappear from scrutiny. From the picture above, it can be noted that in one cycle of a rip current, it took 20-30 seconds until dye balls look no further. Dye movement balls affected by the movement of currents and waves. Rip current in one cycle took about 25-30 minutes until the dye disappeared.

Bathymetry

Bathymetry and the condition of the beach is a factor that is prone to the existence of a rip current (UCAR), There is no seabed morphology control of rip current occurrence at Pangandaran [12]. Bathymetry form near the coast effect on the formation of a rip current that is formed [20]. Rip currently related to the sandbar and the migration of sand towards the restoration of the beachhead.

This also led to occur the presence of variations of longshore current and beach cup which led to spot the existence and periods of rip current [21]. The condition of the bathymetry in Pangandaran and Palabuhanratu can be seen in Figure 5 and Figure 6.

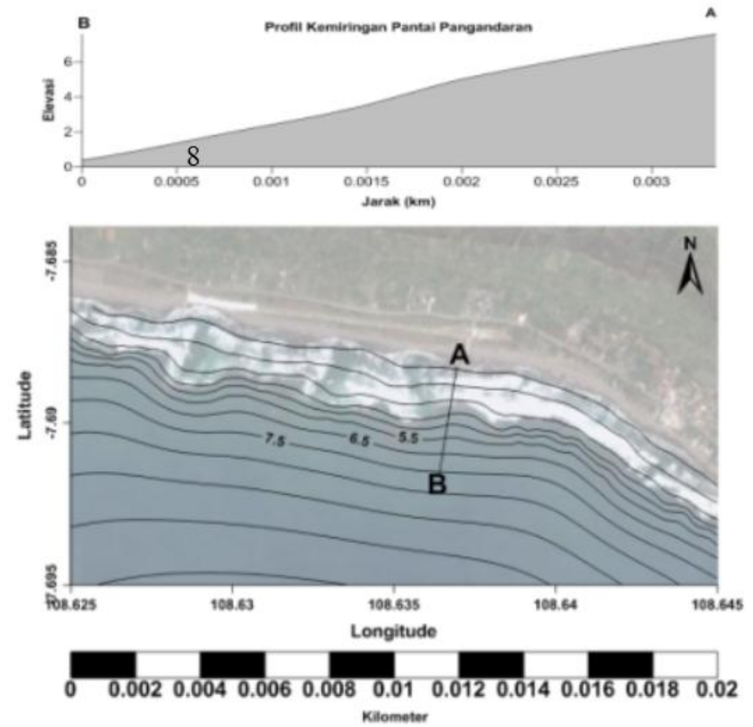

Figure 5. Bathymetry and the slope of the beach at Pangandaran

Pangandaran has an angle of slope of 8°. At Pangandaran, it cannot be found the existence of a mound of sand shoals that are real, but the presence of a slight ridge. On the ridge, it happens the wave smashed into the water masses and forward wholesale swash zone. Bathymetry condition can be seen in Figure 5. Point A is the area of ramps and point B is the deep sea areas. At a depth of 0-4 meters still in beach ramps. At a depth of 5-7 meters including slope. Break zone features into 5-6 meters. The distance from the breaker (surf zone) to the lips of Pangandaran is about 150 meters. Rip current formed in the surf zone which is about 150. Local bathymetry is not observed in the surf zone. The farthest limit of the measurement from shore is 45 meters. Waves that broke out in the surf zone pushed the mass of water enters into the swash zone and spreads [22]. Sandbar is usually formed in the process of changing the topography of wholesale swash zone up to the surf zone [11]. A rip current can occur in a variety of conditions of the bathymetry, even to the beach with a flat bathymetry [2].

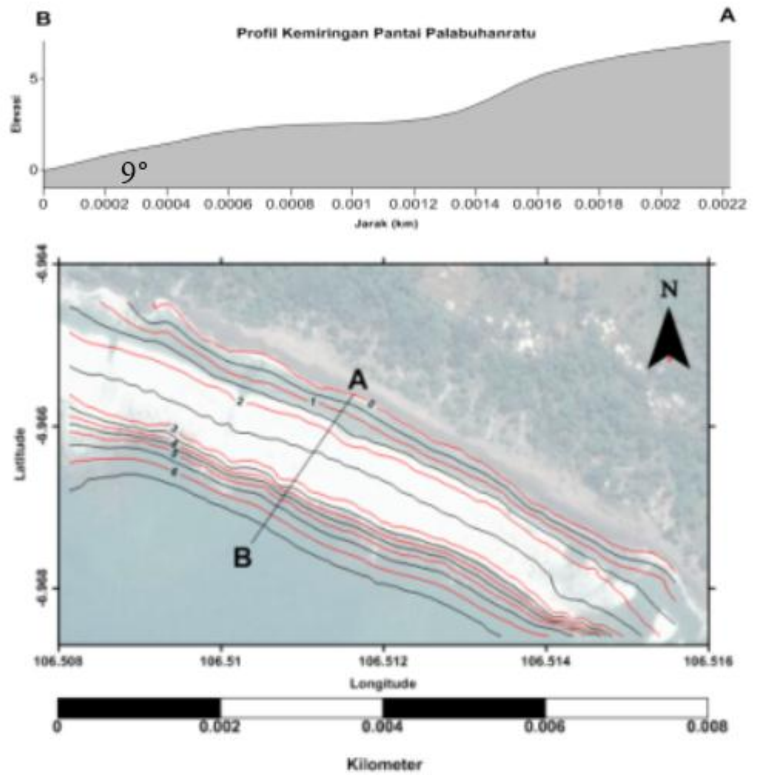

Figure 7. Bathymetry and the slope of the beach at Palabuhanratu

The slope on Palabuhanratu indicates the ridge and valley. Rip current, which it happened, got influences from the slope of the beach at 9°. The sloping beach has a big potential to rip current [23]. Points A and B are about 200 meters away. Break zone has a depth of 5-6 meters. The distance from the coast to the surf zone is up to 120 meters. The depth of swash zone area is 0-3 meters. Rip current on Palabuhanratu is formed in the surf zone which depth is more than 5 meters. The condition of the bathymetry at the beach Palabuhanratu has similarities to Pangandaran, but the distance from the breaker to shore is closer, which is about 120 meters. It indicates that the emergence of the rip current of the surf zone to the shore has a relatively close compared to the rip current at Pangandaran. Along swash zone on the coast of Palabuhanratu, there is no significant difference in depth, but the slope in Palabuhanratu looks steeper when compared to in Pangandaran.

Wave

The Google Earth imagery data shows the direction and angle of coming wave in Pangandaran. The formed rip current shows the wave patterns that converge into each other. The angle and direction of the coming wave in Pangandaran show a pattern of changing every time. As for the angle of the wave in Pangandaran and Palabuhanratu in 2006, it can be seen in Figure 8.

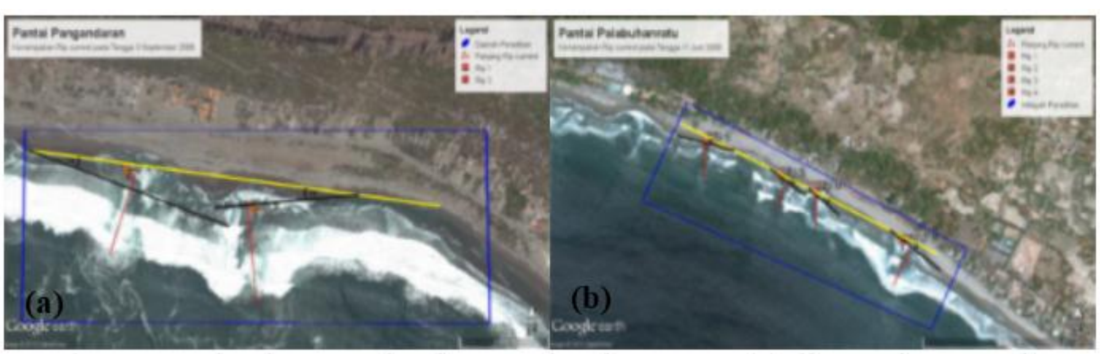

Figure 8. The angle of the wave in 2006; (a) at Pangandaran; (b) at the Palabuhanratu

Figure 8a shows rip current in Pangandaran that was formed in 2006 with the corner come a wave of 10 ° from the shoreline at the stations Rip 1 and 2. This condition causes the occurrence of rip current with complex wave refraction around the site [24]. A wave which angle is more than 5° causes the presence of real longshore current [25]. Figure 8 indicates the coming wave in Palabuhanratu Beach. The angle of the wave in Rip1 is 5°, 3°, 6° and 3°. The angle of the waves on the coast of Palabuhanratu shows the angle that shows the direction the wave is almost parallel to the beach. Waves move parallel straight to the beach. The existence of the rip current at Pangandaran can be seen in the break zone [3,26]. At the time of going broke, there are differences of turbidity in the waves. The level of turbidity in the water mass shows wave body containing sediments due to previous waves. Sediments stirred by the waves will get carried away towards the sea due to a rip current [27]. This suggests the existence of an interaction between current waves with bathymetry. The interaction of the current wave may indicate the system and mechanism of a rip current that is formed [2]. The wave is moving towards the coast brought the water and back towards the sea after reaching shore [26,28]. High wave affect-ed on the speed of the rip current that occurs. The bigger wave may be the cause of the current which increase rip speed accompanied by declining levels into an aquatic [2]. Figure 8b is a condition of the wave on the Palabuhanratu. The waves on the Palabuhanratu come almost parallel with the shoreline angle of 5°. It causes the existence of longshore current formed due to the direction of the waves or the condition of the bathymetry near the coast. The morphology of the coast Palabuhanratu also shows the morphology of the same cup with the beach in Pangandaran. The wave conditions at Pangandaran and Palabuhanratu can be seen in table 2.

Table 2. The data of Wave at Pangandaran and Palabuhanratu.

Location	Station	θ (°)	C (m/s)	Hs (m)	T (s)
Pangandaran	1	<5	1.47	1.529	3.73
	2	<5	1.51	1.319	3.75
Palabuhanratu	1	5	1.13	1.216	4.41
	2	5	1.04	1.959	4.35

Based on table 2, it can be shown that the wave condition in Pangandaran has a speed of 1.47 m/s and 1.51 m /s. Significant height (Hs) was 1,529 at station 1 and 1,319 at station 2. It shows the average maximum height of the wave. Wave velocity in Pangandaran is larger at station 2, namely 1.51 m /s with the significant wave height is the highest in station 1, namely 1,529 m. In general, higher speeds and significant waves in Pangandaran stations do not very much. The wave direction is parallel to the beach with the angle of incidence of less than 5 °. Wave period is 3.73 seconds at station 1 and station 2. 3.75 Second wave velocity in the larger Palabuhanratu located at Station 1, namely 1.13 m/s whereas a significant height (Hs) the biggest waves in the station 2, namely 1,959 m. Wave period in Palabuhanratu station is larger when compared with the period of the waves near Pangandaran, namely 4.41 seconds and 4.35 seconds. The speed of the wave in Pangandaran is larger compared to the speed of the wave at Palabuhanratu. Wave period in Pangandaran and Palabuhanratu including on WPR (Wave Period Rating) 3 and the WHR (Wave Height Rating) 4 which shows the wave conditions are harmless [29]. The type of broken wave in Pangandaran and Palabuhanratu is plunging wave [30]. The wave in Pangandaran and Palabuhanratu is caused by the wind that blows from the Southeast. Constructive waves are carrying sediment and takes part in the formation of morphological beach cup.

Conclusion

The existences of rip currents at Pangandaran and Palabuhanratu takes place every year with the determining factors of rip currents are currents, waves, and near-shore bathymetry. Based on the characteristics of the constituent factors, the type of rip currents at Pangandaran and Palabuhanratu is Accretionary beach rip Topographic beach rip. Rip current formation process begins with the coming wave passing through surf zone then deflected by the longshore current and returned to the sea away from the shore.

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